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Exploring metal zoning in metapelitic porphyroblasts to reconstruct reaction histories and P-T-t-D paths

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In this contribution we examine the record of metamorphism as preserved by trace-element zoning across major-, minor-, and accessory minerals: some of these are both thermobarometers and petrochronometers (e.g., garnet by Lu-Hf & Sm-Nd, micas by Rb-Sr). Of primary concern is the sequestration, liberation, intergranular diffusion, and partitioning behavior of slow-diffusing metals during progressive metamorphism of a clay-rich protolith (metapelite). These protoliths are typically endowed with a suite of elements that are enriched relative to the average continental crust: Li, Cs, Ba, the transition metals Co-Ni-Cu-Zn, post-transition metals Sn-Tl-Pb, metalloids As-Sb-Te, and high-field strength elements Mo-W. Zoning in these elements helps fingerprint metamorphic reaction histories and supplements Y-REE zoning in thermochronometers like garnet. Here we examine this problem by: 1) assessing trace-element content for all major, minor, and accessory phases in two metapelitic schists along the same prograde sequence; 2) calculating elemental budgets using micro-XRF phase mapping; 3) characterizing trace-metal zoning in aluminosilicates (garnet, biotite, chlorite, staurolite, chloritoid, plagioclase) and oxides (ilmenite); and 4) assessing potential reaction histories along a simple prograde *P-T* path derived from thermodynamic modeling.

LA ICP-MS trace-element mapping and spot analyses reveals first-order metal fractionation: Li and Zn into staurolite; P, Pb, Sr, LREE and Ga into plagioclase; Li, V, Cr, Co, Ni, Zn, Rb, Sn, Cs, and Tl in micas; chlorite has the highest affinity for Li, Ni and Zn among the sheet silicates; chloritoid also shows an affinity for Zn, Ge, and In. More importantly, well-preserved zoning for compatible trace elements can help reconstruct the metamorphic reaction history. In garnet a combination of Y, Li, Eu/Eu*, Sm, and HFSE can be used to reconstruct changing reaction history among Y-rich accessory minerals, chlorite, plagioclase, ilmenite and micas. Zoning s unmodified by diffusive re-equilibration and preserves evidence for discontinuous and continuous reactions. Biotite preserves zoning in Cr, Cs, Nb and Sn that could related to progressive consumption of chlorite, muscovite, and ilmenite.

When combined with spatially-resolved geochronology this approach adds extra dimensions to the record of metamorphic *P-T-t-D* paths and takes advantage of porphyroblasts zoning patterns that are largely unexplored.